141. (Unamended) A semiconductor device according to claim 140, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

REMARKS

This is in response to the Office Action dated February 26, 2003. Claims 29-141 are pending. Attached hereto is a marked-up version of the changes made to the claim(s) by the current amendment. The attached page(s) is captioned "Version With Markings To Show Changes Made."

Claim 29 stands rejected under 35 U.S.C. Section 102(b) as being allegedly anticipated by Adomi. This Section 102(b) rejection is respectfully traversed for at least the following reasons.

Claim 29 requires a "crystal growth method for adding or crystallizing nitrogen in a crystal supported by a substrate, comprising: <u>supplying aluminum and ammonium (NH_3) to a surface of the crystal</u>, wherein addition or crystallization of the nitrogen from the <u>ammonium which is supplied to the surface of the crystal</u> into the surface of the crystal is accelerated by the <u>aluminum supplied to the surface of the crystal</u>." In other words, claim 29 requires supplying aluminum and ammonium directly onto the surface of a crystal. Thus, surprisingly, there is utilized a phenomenon of accelerating the surface absorption and accelerating the surface dissolution of ammonium by way of aluminum at the surface. This is applicable, for example, to a method of growing a crystal, such as

MBE or GB-MBE method, without necessarily needing a gaseous reaction between the ammonium and aluminum.

In contrast, Adomi <u>fails</u> to disclose or suggest supplying aluminum and ammonium directly onto the surface of a crystal. Adomi grows a crystal of AlGaPN via a MO CVD method. TMAI is an Al source, ammonium a N source; so that as explained by Adomi when the Al is mix-crystallized N concentration in the crystal is increased. Adomi explains that when ammonium is used as an N source, an adduct (TMAI:ammonium) is formed between the ammonium and TMAI and the chemical bonding between Al and N plays a role when N is doped in AlGaP. Importantly, since MO-CVD and CBE methods are used in Adomi to grow a crystal of AlGaPN, the reference uses an intermediate product produced by reaction within gaseous phase between ammonium and an organic compound of Al *without employing the surface of the substrate*. Thus, it can be seen that Adomi fails to disclose or suggest supplying aluminum and ammonium directly onto the surface of a crystal as required by claim 29. The claim cannot be anticipated.

With respect to claims 63 and 100, the cited art also fails to disclose or suggest supplying aluminum and ammonium directly onto the surface of a crystal.

With respect to claims 42, 79 and 116, these claims require that <u>crystal growth is performed by applying a source material to a substrate in a crystal growth room which is evacuated of air, and a mean free path of a molecule of each source material is longer than a distance between the substrate and a source of the source material</u>. With such an arrangement, since the source materials need not cause a gaseous reaction with each other

in a crystal growth room, there is no generation of adduct of intermediate product. This of course is the exact opposite of what Adomi requires. Again, the cited art fails to disclose or suggest the subject matter of these claims.

With respect to claims 43, 80 and 117, these claims require ammonium in the form of gas is used as a nitrogen source material, and a source material of another element is obtained by evaporating a solid of a single element (e.g., such as a material corresponding to a molecular line in MBE method). Accordingly, since an organic gaseous compound of Al is not employed, there is no generation of adduct of intermediate product by way of gaseous reaction between ammonium and an aluminum organic material (TMAC) as in Adomi. Again, Adomi fails to disclose or suggest the subject matter of these claims, and in fact teaches directly away from the same.

With respect to claims 44, 81 and 118, these claims require that ammonium in an undecomposed state is supplied as a nitrogen source material and decomposed on a surface of the substrate. Since the variation of molecular combination or reaction within a gaseous phase between ammonium and other source gas(es) is not generated, there is no generation of adduct of intermediate product by way of a gaseous reaction between ammonium and an organic material (TMAI) of Al as in Adomi. Again, Adomi fails to disclose or suggest the subject matter of these claims, and in fact teaches directly away from the same.

For at least the foregoing reasons, it is respectfully requested that all rejections be withdrawn. All claims are in condition for allowance. If any minor matter remains to be resolved, the Examiner is invited to telephone the undersigned with regard to the same.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS

29. (Amended) A crystal growth method for adding or crystallizing nitrogen in a crystal supported by a substrate, comprising:

[a step of]supplying aluminum and ammonium (NH_3) to a surface of the crystal,

wherein addition or crystallization of the nitrogen from the ammonium which is supplied to the surface of the crystal into the surface of the crystal is accelerated by the aluminum supplied to the surface of the crystal.

30. (Unamended) A crystal growth method according to claim 29, wherein decomposition of ammonium and adsorption of nitrogen on a crystal surface is accelerated by aluminum.

31. (Unamended) A crystal growth method according to claim 29, wherein the aluminum exists at least in an outermost surface of a growing layer.

32. (Unamended) A crystal growth method according to claim 29, wherein an amount of nitrogen added to a crystal, a nitrogen composition, an amount of nitrogen adsorbed on a crystal surface and an amount of an element in the crystal surface which is substituted with a nitrogen atom are controlled based on an amount or composition ratio of added aluminum.

33. (Unamended) A crystal growth method according to claim 29, wherein aluminum is added to or crystallized in a restricted region, whereby only in the restricted region, nitrogen is added or crystallized, a nitrogen atom is adsorbed, or an element in a crystal surface is substituted with a nitrogen atom.

34. (Unamended) A crystal growth method according to claim 29, wherein a method selected from among a molecular beam epitaxial (MBE) growth method, a metal organic molecular beam epitaxial (MO-MBE) growth method, a gas source molecular beam epitaxial (GS-MBE) growth method, and a chemical beam epitaxial (CBE) growth method is used.

35. (Unamended) A crystal growth method according to claim 29, wherein crystal growth of a Ill-V compound semiconductor including, as V group components, nitrogen and a V group element other than nitrogen is performed.

36. (Unamended) A crystal growth method according to claim 35, wherein at least one of arsenic (As), phosphorus (P), and antimony (Sb) is selected as the V group element other than nitrogen.

37. (Unamended) A crystal growth method according to claim 35, wherein a substrate temperature is in a range from 450^0C to 640^0C.

39. (Unamended) A crystal growth method according to claim 38, wherein the slant angle is within a range equal to 2^0 or more and equal to 25^0 or less.

40. (Unamended) A crystal growth method according to claim 29, wherein one or more pairs of semiconductor layer A and semiconductor layer B are superposed, the semiconductor layer A including at least aluminum and nitrogen in its composition but not including indium in its composition, and the semiconductor layer B including at least indium in its composition but not including nitrogen in its composition.

41. (Amended) A crystal growth method according to claim 40, wherein the thickness of each of the semiconductor layers A and B is from one to ten molecular layers [or more, and ten molecular layers or less].

42. (Unamended) A crystal growth method according to claim 29, wherein crystal growth is performed by applying a source material to a substrate in a crystal growth room which is evacuated of air, and a mean free path of a molecule of each source material is longer than a distance between the substrate and a source of the source material.

43. (Unamended) A crystal growth method according to claim 29, wherein ammonium in the form of gas is used as a nitrogen source material, and a source material of another element is obtained by evaporating a solid of a single element.

44. (Unamended) A crystal growth method according to claim 29, wherein ammonium in an undecomposed state is supplied as a nitrogen source material and decomposed on a surface of the substrate.

45. (Unamended) A crystal growth method according to claim 29, wherein crystal growth is performed over an underlying (sub-strate) crystal which does not include nitrogen as a principal element.

46. (Unamended) A crystal growth method according to claim 45, wherein the underlying (substrate) crystal is selected from GaAs, InP, GaP, GaSb, and Si.

47. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 29.

48. (Unamended) A semiconductor device according to claim 47, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

49. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 38.

50. (Unamended) A semiconductor device according to claim 49, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

51. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 40.

52. (Unamended) A semiconductor device according to claim 51, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

53. (Amended) [A system] <u>An apparatus</u> which uses the semiconductor device of claim 47.

54. (Amended) [A system] <u>An apparatus</u> which uses the semiconductor device of claim 49.

55. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 42.

56. (Unamended) A semiconductor device according to claim 55, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

57. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 43.

58. (Unamended) A semiconductor device according to claim 29, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

59. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 44.

60. (Unamended) A semiconductor device according to claim 59, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

61. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 45.

62. (Unamended) A semiconductor device according to claim 61, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

63. (Unamended) A crystal growth method for adsorbing a nitrogen atom on a surface of a crystal, the crystal including aluminum in the surface thereof, comprising steps of:

growing the crystal including the aluminum on the surface; and

supplying ammonium (NH_3) to the surface of the crystal including the aluminum in the surface thereof,

wherein adsorption of the nitrogen atom generated by decomposition of the ammonium supplied to the surface of the crystal is accelerated by the aluminum included in the surface of the crystal.

64. (Unamended) A crystal growth method according to claim 63, wherein decomposition of ammonium and adsorption of nitrogen on a crystal surface is accelerated by aluminum.

65. (Unamended) A crystal growth method according to claim 63, wherein the aluminum exists at least in an outermost surface of a growing layer.

66. (Unamended) A crystal growth method according to claim 63, wherein an amount of nitrogen added to a crystal, a nitrogen composition, an amount of nitrogen adsorbed on a crystal surface and an amount of an element in the crystal surface which is substituted with nitrogen are controlled based on an amount or composition ratio of added aluminum.

67. (Unamended) A crystal growth method according to claim 63, wherein aluminum is added to or crystallized in a re-stricted region, whereby only in the restricted region, nitrogen is added or crystallized, a nitrogen atom is adsorbed, or an element in a crystal surface is substituted with a nitrogen atom.

68. (Unamended) A crystal growth method according to claim 63, wherein a method selected from among a molecular beam epitaxial (MBE) growth method, a metal organic molecular beam epitaxial (MO-MBE) growth method, a gas source molecular beam epitaxial (GS-MBE) growth method, and a chemical beam epitaxial (CBE) growth method is used.

69. (Unamended) A crystal growth method according to claim 63, wherein crystal growth of a III-V compound semiconductor including, as V group components, nitrogen and a V group element other than nitrogen is performed.

70. (Unamended) A crystal growth method according to claim 69, wherein at least one of arsenic (As), phosphorus (P), and antimony (Sb) is selected as the V group element other than nitrogen.

71. (Unamended) A crystal growth method according to claim 69, wherein a substrate temperature is in a range from 450^0C to 640^0C.

72. (Unamended) A crystal growth method according to claim 63, comprising a series of steps including at least steps of:

supplying a III group source material including aluminum of less than one atomic layer;

subsequently, supplying ammonium so as to adsorb nitrogen atoms of less than one atomic layer; and

supplying a source material of a V group element other than nitrogen,

wherein the series of steps are repeated one time or more.

73. (Unamended) A crystal growth method according to claim 72, wherein in the step of supplying ammonium so as to adsorb nitrogen of less than one atomic layer, the source material of the V group element other than nitrogen is not supplied at the same time.

74. (Unamended) A crystal growth method according to claim 72, wherein crystal growth is performed over a single crystal substrate in which a (100) surface is a principal plane.

76. (Unamended) A crystal growth method according to claim 75, wherein the slant angle is within a range equal to 2^0 or more and equal to 25^0 or less.

77. (Unamended) A crystal growth method according to claim 63, wherein one or more pairs of semiconductor layer A and semiconductor layer B are superposed, the semiconductor layer A including at least aluminum and nitrogen in its composition but not including indium in its composition, and the semiconductor layer B including at least indium in its composition but not including nitrogen in its composition.

78. (Amended) A crystal growth method according to claim 77, wherein the thickness of each of the semiconductor layers A and B is <u>from</u> one <u>to ten</u> molecular layer<u>s</u> [or more, and ten molecular layers or less].

79. (Unamended) A crystal growth method according to claim 63, wherein crystal growth is performed by applying a source material to a substrate in a crystal growth room which is evacuated of air, and a mean free path of a molecule of each source material is longer than a distance between the substrate and a source of the source material.

80. (Unamended) A crystal growth method according to claim 63, wherein ammonium in the form of gas is used as a nitrogen source material, and a source material of another element is obtained by evaporating a solid of a single element.

81. (Unamended) A crystal growth method according to claim 63, wherein ammonium in an undecomposed state is supplied as a nitrogen source material and decomposed on a surface of the substrate.

82. (Unamended) A crystal growth method according to claim 63, wherein crystal growth is performed over an underlying (substrate) crystal which does not include nitrogen as a principal element.

83. (Unamended) A crystal growth method according to claim 82, wherein the underlying (substrate) crystal is selected from GaAs, EnP, GaP, GaSb, and Si.

84. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 63.

85. (Unamended) A semiconductor device according to claim 84, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

86. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 75.

87. (Unamended) A semiconductor device according to claim 86, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

88. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 77.

89. (Unamended) A semiconductor device according to claim 88, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

90. (Amended) [A system] <u>An apparatus</u> which uses the semiconductor device of claim 84.

91. (Amended) [A system] <u>An apparatus</u> which uses the semiconductor device of claim 88.

92. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 79.

93. (Unamended) A semiconductor device according to claim 92, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

94. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 80.

95. (Unamended) A semiconductor device according to claim 94, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

96. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 81.

97. (Unamended) A semiconductor device according to claim 96, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

98. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 82.

99. (Unamended) A semiconductor device according to claim 98, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

100. (Amended) A crystal growth method for substituting a portion of elements included in a crystal surface with nitrogen atoms, the surface of the crystal further including aluminum, comprising steps of:

growing the crystal; and

supplying ammonium (NH_3) <u>and aluminum</u> to the surface of the crystal,

wherein substitution of the portion of the elements with the nitrogen atom from the ammonium supplied to the surface of the crystal is accelerated by the aluminum included in the surface of the crystal.

101. (Unamended) A crystal growth method according to claim 100, wherein decomposition of ammonium and adsorption of nitrogen on a crystal surface is accelerated by aluminum.

102. (Unamended) A crystal growth method according to claim 100, wherein the aluminum exists at least in an outermost surface of a growing layer.

103. (Unamended) A crystal growth method according to claim 100, wherein an amount of nitrogen added to a crystal, a nitrogen composition, an amount of nitrogen

adsorbed on a crystal surface and an amount of an element in the crystal surface which is substituted with nitrogen are controlled based on an amount or composition ratio of added aluminum.

104.(Unamended) A crystal growth method according to claim 100, wherein aluminum is added to or crystallized in a re-stricted region, whereby only in the restricted region, nitrogen is added or crystallized, a nitrogen atom is adsorbed, or an element in a crystal surface is substituted with a nitrogen atom.

105. (Unamended) A crystal growth method according to claim 100, wherein a method selected from among a molecular beam epitaxial (MBE) growth method, a metal organic molecular beam epitaxial (MO-MBE) growth method, a gas source molecular beam epitaxial (GS-MBE) growth method, and a chemical beam epitaxial (CBE) growth method is used.

106. (Unamended) A crystal growth method according to claim 100, wherein crystal growth of a III-V compound semiconductor including, as V group components, nitrogen and a V group element other than nitrogen is performed.

107. (Unamended) A crystal growth method according to claim 106, wherein at least one of arsenic (As), phosphorus (P), and antimony (Sb) is selected as the V group element other than nitrogen.

108. (Unamended) A crystal growth method according to claim 106, wherein a substrate temperature is in a range from 450^0C to 640^0C.

109. (Unamended) A crystal growth method according to claim 100, comprising a series of steps including at least steps of:

forming a 111-V compound crystal layer including at least one molecular layer of aluminum; and subsequently, supplying ammonium so as to substitute a portion of V group atoms in the 111-V compound crystal layer with nitrogen atoms, wherein the series of steps are repeated one time or more.

110. (Unamended) A crystal growth method according to claim 100, comprising at least steps of:

crystal-forming a layered structure including at least a first semiconductor layer containing aluminum and a second semiconductor layer superposed thereon;

etching the layered structure while masking a portion of the layered structure such that the first semiconductor layer is exposed in a portion of an etched surface; and

supplying ammonium to the etched surface while heating the layered structure such that at least a portion of a constituent element in the first semiconductor layer is substituted with nitrogen.

111. (Amended) A crystal growth method according to claim 110, wherein the etched surface is a (nll)A surface [(n=1, 2, 3,...).] <u>(n= 1, 2 or 3).</u>

113. (Unamended) A crystal growth method according to claim 112, wherein the slant angle is within a range equal to 2^0 or more and equal to 25^0 or less.

114. (Unamended) A crystal growth method according to claim 100, wherein one or more pairs of semiconductor layer A and semiconductor layer B are superposed, the semiconductor layer A including at least aluminum and nitrogen in its composition but not including indium in its composition, and the semiconductor layer B including at least indium in its composition but not including nitrogen in its composition.

115. (Amended) A crystal growth method according to claim 114, wherein the thickness of each of the semiconductor layers A and B is <u>from</u> one <u>to ten</u> molecular layer<u>s</u> [or more, and ten molecular layers or less].

116. (Unamended) A crystal growth method according to claim 100, wherein crystal growth is performed by applying a source material to a substrate in a crystal growth room which is evacuated of air, and a mean free path of a molecule of each source material is longer than a distance between the substrate and a source of the source material.

117. (Unamended) A crystal growth method according to claim 100, wherein ammonium in the form of gas is used as a nitrogen source material, and a source material of another element is obtained by evaporating a solid of a single element.

118. (Unamended) A crystal growth method according to claim 100, wherein ammonium in an undecomposed state is supplied as a nitrogen source material and decomposed on a surface of the substrate.

119. (Unamended) A crystal growth method according to claim 100, wherein crystal growth is performed over an underlying (substrate) crystal which does not include nitrogen as a principal element.

120. (Unamended) A crystal growth method according to claim 119, wherein the underlying (substrate) crystal is selected from GaAs, InP, GaP, GaSb, and Si.

121. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 100.

122. (Unamended) A semiconductor device according to claim 121, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

123. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 112.

124. (Unamended) A semiconductor device according to claim 123, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

125. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 114.

126. (Unamended) A semiconductor device according to claim 125, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

127. (Unamended) A method for forming a semiconductor microwire structure wherein:

the crystal growth method of claim 110 is used when forming a semiconductor microstructure having a periodically-positioned wire pattern;

a diffraction grating is formed by the step of etching the layered structure while masking a portion of the layered structure such that the first semiconductor layer is exposed in a portion of an etched surface; and

a periodical wire structure is formed at a 1/2 of the pitch of the diffraction grating by the step of supplying ammonium to the etched surface while heating the layered structure such that at least a portion of a constituent element in the first semiconductor layer is substituted with nitrogen.

128. (Unamended) A method for forming a semiconductor microwire structure according to claim 127, wherein the wire structure is an absorptive diffraction grating section of a gain-coupled distributed feedback semiconductor laser having an absorptive diffraction grating, or a quantum wire.

129. (Unamended) A method for forming a semiconductor microwire structure according to claim 127, wherein ammonium in an undecomposed state is supplied as a nitrogen source material and decomposed on a surface of the substrate.

130. (Unamended) A method for forming a semiconductor microwire structure according to claim 127, wherein crystal growth is performed over an underlying (substrate) crystal which does not include nitrogen as a principal element.

131. (Unamended) A method for forming a semiconductor microwire structure according to claim 130, wherein the underlying (substrate) crystal is selected from GaAs, InP, GaP, GaSb, and Si.

132. (Amended) [A system] <u>An apparatus</u> which uses the semiconductor device of claim 121.

133. (Amended) [A system] <u>An apparatus</u> which uses the semiconductor device of claim 123.

134. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 116.

135. (Unamended) A semiconductor device according to claim 134, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

136. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 117.

137. (Unamended) A semiconductor device according to claim 136, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

138. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 118.

139. (Unamended) A semiconductor device according to claim 138, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.

140. (Unamended) A semiconductor device comprising a semiconductor layer formed by the crystal growth method of claim 119.

141. (Unamended) A semiconductor device according to claim 140, wherein the semiconductor device is a light emitting element, and the semiconductor layer forms a light emitting layer thereof.